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Trout Farming in Washington

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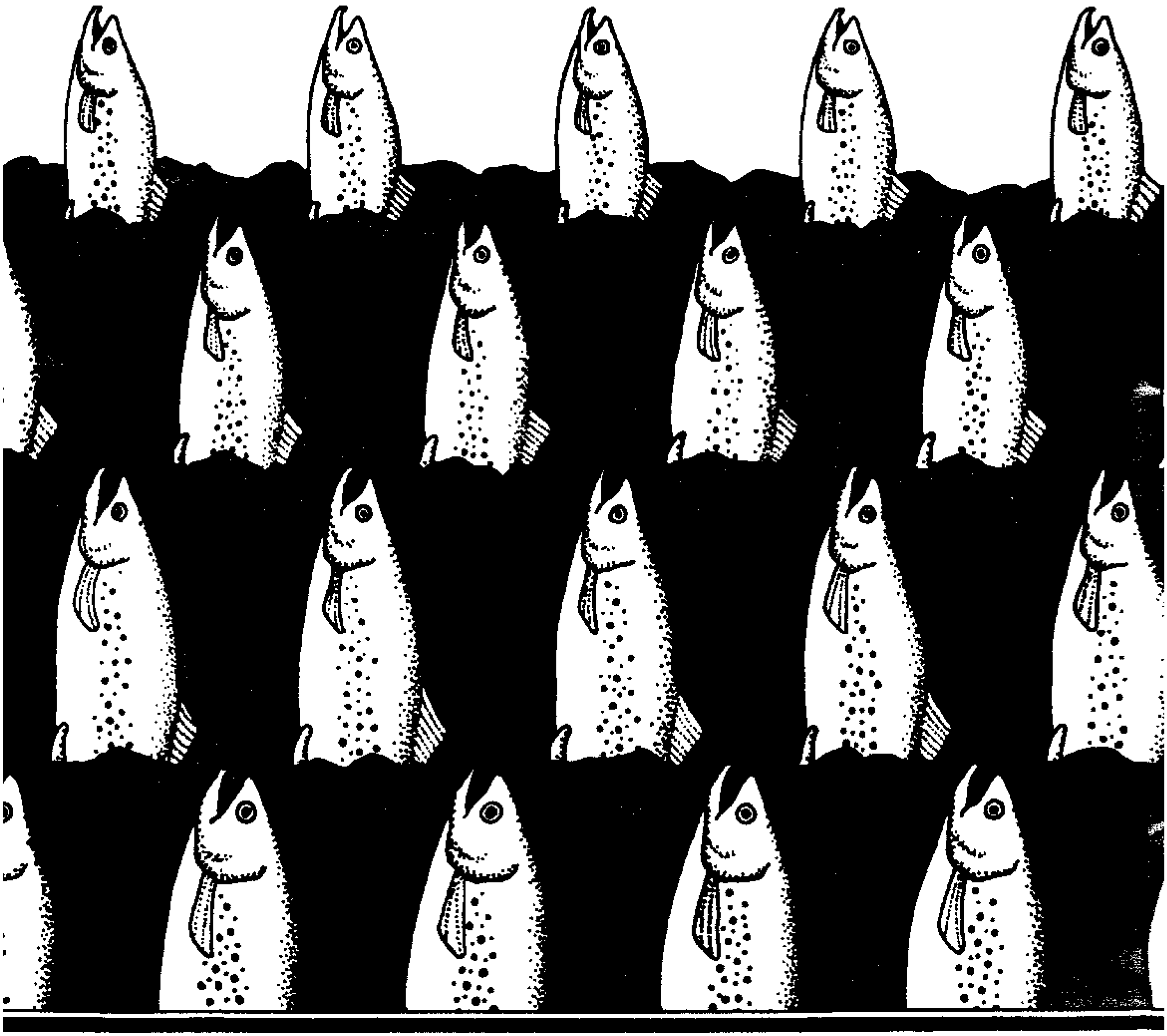

Cooperative Extension
College of Agriculture
Washington State University

Contents

TROUT FARMING IN WASHINGTON

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Fish farming began in Asia over 4,000 years ago as part of a small-scale agricultural economy. Today farm fish ponds in Washington can be used to produce trout and salmon for personal use or commercially for the production of eggs, fingerlings, or market-size fish. In addition, ponds can be used for recreation, irrigation, and wildlife habitat.

Only farm ponds properly planned and constructed can fulfill their intended purpose. Certain basic principles must be followed in design and construction, if you want the kind of pond you need with the least expense and labor.

Growing fish can be classified into two categories, raising fish for your own recreational use, and raising fish to sell for profit. Fish farming as a major source of income can be a time-consuming, high-risk business, so before you go into commercial production, give plenty of thought to the operation. However, growing fish on a few acres can be enjoyable and profitable, if properly managed.

Topography, water, soil, and other resources will influence or limit your success in raising fish.

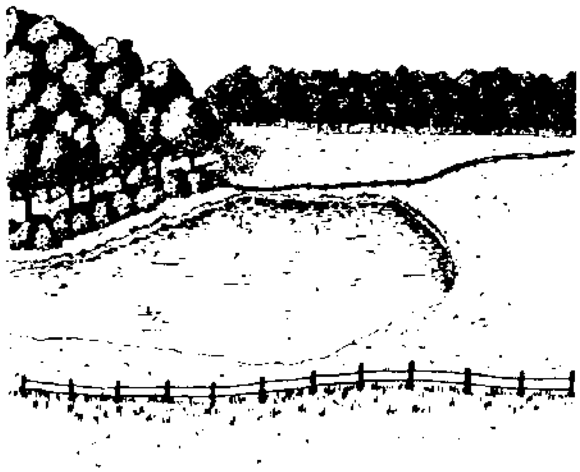

Figure 1. A trout pond requires good planning to become an attractive part of your property.

THINGS TO CONSIDER FIRST

Site Selection

The first important decision you need to make is to select the site. For good fish production the pond should be located where sufficient depth, suitable soil, and the best possible water supply can be obtained. Your land must contain a site suitable for impounding water at reasonable cost.

There are three types of construction methods to consider: the embankment, the dugout, or a combination of these two. The embankment type is created by damming surface runoff or spring flow. A dugout pond is constructed so that little or no water is stored above the original ground level. Probably the most common is a combination—partly dugout and partly embankment—with water supplied by spring flow, surface runoff, or a combination of both. (See Fig. 2.)

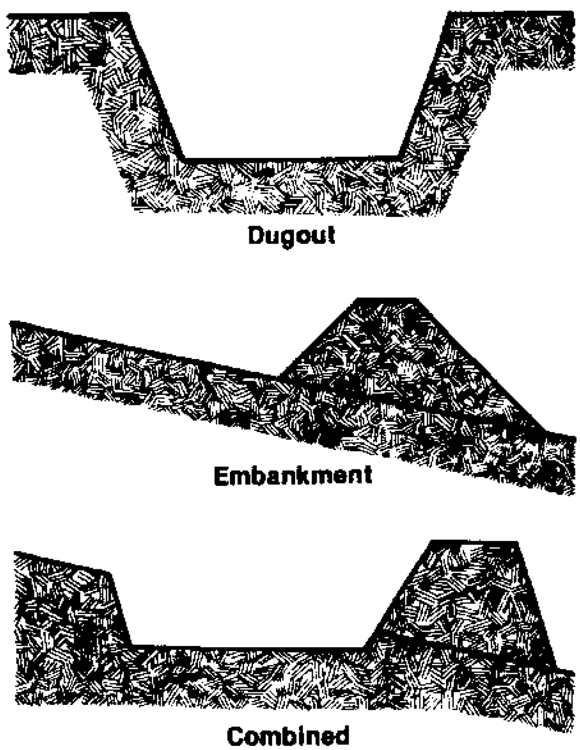

Figure 2. Three types of pond construction that can be used in various situations.

The watershed above the pond should be large enough to keep water in the pond during dry periods, yet not so large that it will create flood hazards during heavy rainstorms. Watersheds of between 10 and 30 acres with a good cover of grass, trees, or shrubs are best.

To make sure your pond will hold water after it is built, bore or dig test holes to find the kind and depth of soil at the pond site you are considering. Look for soil that will hold water well enough to prevent excessive seepage, such as heavy clay. Unless you can dig your pond below the water table, avoid sites having sandy or gravelly soil through which the water might seep. If seepage is too great, it may be possible to seal the pond bottom with a layer of clay or with bentonite.

Water Supply

The amount and quality of available water will determine the size of the pond and the number of fish you can raise. Do you have surface runoff, a flowing spring, or underground seepage? You can estimate surface runoff by considering the area and characteristics of the watershed and the annual rainfall. Spring water can be measured by timing the filling of a container of known capacity. To estimate the amount of underground seepage, measure the slope in the groundwater table, soil permeability, and the cross section of the pond.

A good fish pond must have enough spring flow, well water, or runoff to maintain good water quality and replenish water loss through evaporation and seepage.

The key to the success or failure of your operation is the quality of the water in the pond. The water should have the following characteristics:

Temperature. Water between 50 and 65°F is ideal for best growth of adults, and water 48 to 56°F is most suitable for hatching trout eggs. Lower temperatures result in slower growth. Temperatures up to 78°F can be tolerated only for short periods by adult fish, but prolonged temperatures above 70 may lead to disease problems.

Oxygen. Water must have a dissolved oxygen content of at least 6 parts per million or above. If supplemental feed is not used, you will probably not have to test this because most cool water ponds (cooler than 75°F) have enough oxygen, if stocked with fish at the recommended rates. However, when supplemental feed or fertilizer is being used, a dissolved oxygen meter is recommended.

Other Characteristics. The water must be free of silt and pollutants and should be within an acidity alkalinity range of pH 6.5 to 9. However, trout can survive acidic water as low as pH 4.5, but growth rate is low.

Water from wells and some springs is sometimes low in oxygen but high in noxious gases. Aerating this water by spraying or running it over baffles reduces gas supersaturation problems and adds oxygen.

There is no easy rule for determining whether the water in your pond is suitable for trout. However, if surface water temperatures remain below 70 to 75°F, usually the water will support trout.

If you already have a pond, one way to test the water is to put a screen box, called a live box, containing a few trout in the pond for a few days. If you think water temperature might be a problem, make your live box test during hot weather.

Pond Construction

A pond built and managed exclusively for trout will produce more fish than a dual-purpose pond. However, you may be sacrificing aesthetic or recreational value for increased fish production.

Size. Trout can be raised in almost any size pond as long as water quality is good and food is available.

An irregular shaped pond usually has a more pleasing appearance than a circular or square-cornered pond. However, if good quality water is available year-round, a smaller pond or raceway can be used. With this design, the fish may require supplemental feeding because of the small amount of natural food available. Base the size of your pond on the average, not maximum, water supply and remember that a large pond costs more to build and maintain.

If possible, make a topographic survey of the pond site and watershed from which detailed plans showing the dam and other features can be made. Proper pond design is important and careful planning at this stage will eliminate future problems. On site assistance for pond construction is available at your local USDA Soil Conservation Service Office.

Depth. The depth needed for a trout pond depends largely on water supply and climate. In eastern Washington, where summer temperatures are high and ponds freeze over in winter, one-fourth of the pond should be at least 10 feet deep, if it is without running water. Depths of 6 to 8 feet are usually adequate in western Washington, or where there is running water.

The shore of the pond should have a steep slope of 3 to 1 or steeper and as little water as possible less than 3 feet deep to avoid aquatic weed growth and mosquitoes (Fig. 3). Plant grass or

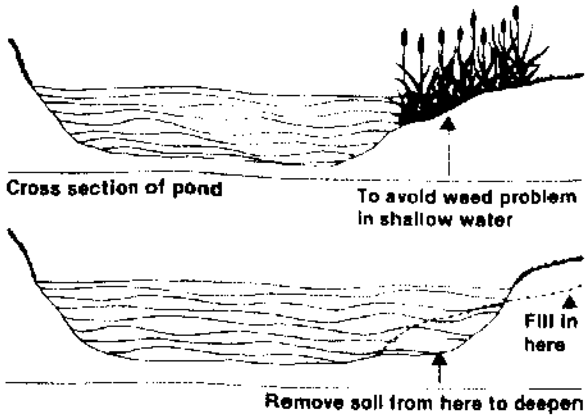

Figure 3. Shallow water near shore encourages weed growth.

other low growing ground cover to prevent erosion and control weeds.

Spillways. Because spillway design and watershed hydrology are fairly technical engineering problems, you should consult with a professional engineer or your local USDA Soil Conservation Service engineer.

Pipe and Side Spillway. The size and type of spillway are important because too small a spillway can easily lead to the complete failure of your pond. A combination pipe spillway and side spillway is best (Fig. 4). The normal flow from springs or light runoff goes through the pipe spillway, and heavy runoff is handled by the side spillway, which can be planted in sod-forming grass or low ground cover.

The bottom of the side spillway must be higher than the top of the pipe spillway. The distance, in height, between the bottom of the side spillway and the inlet of the pipe spillway has been designated as "S." This distance ("S") will vary, according to the size of the watershed and the size of the pond. To determine how much the distance should be, divide the area of the watershed in acres by the surface area of the pond in acres and divide the result by six. This will give you "S" in feet. For example, if you have a watershed area of 18 acres

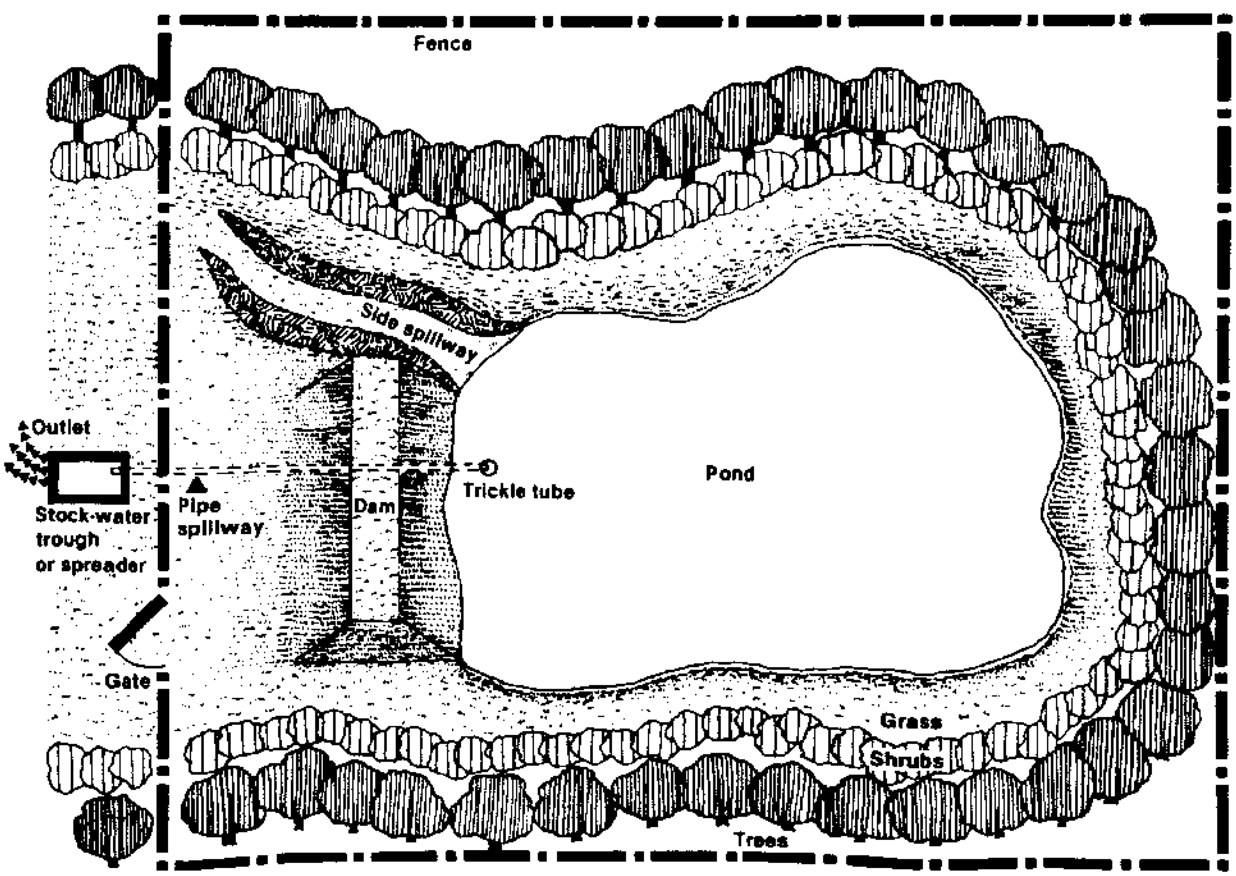

Figure 4. General view of a farm pond layout.

and the surface area of your pond is to be 2 acres, than "S" will be: $18 \div 2 = 9$, $9 \div 6 = 1\frac{1}{2}$ feet. This means that the bottom of the side spillway should be 1½ feet higher than the top of the pipe spillway for this particular pond. The distance in height ("S") should not be less than 1 foot or greater than 3 feet. Otherwise an experienced engineer should plan a different type of spillway. By allowing the proper distance between the pipe spillway and the side spillway, the sizes for spillways listed in Table 1 should give satisfactory results.

Table 1. Size of Spillways

Watershed area (A.)	Diameter of pipe spillway (In.)	Bottom width of side spillway (Ft.)
10	6	8 to 10
10 to 20	8	10 to 15
20 to 30	10	15 to 20

Increase the bottom width of the side spillway 1 foot for each 2-acre increase in watershed greater than 10 acres.

If you build the side spillway wider than needed for discharging flood water, you will lose fewer fish during runoff. This is because the wider spillway results in more shallow water, discouraging fish passage. Never screen the side spillway.

Pipe Spillway. Trickle tube is the common name for the pipe spillway. It is usually constructed of metal or concrete pipe and consists of a vertical section of pipe serving as an inlet that connects with the pipe running through the bottom of the dam. The height of the trickle tube determines the level of the water in the pond.

If the trickle tube is placed inside a riser pipe (Fig. 5), you can direct the pond outflow through either the surface outlet gate or the bottom outlet pipe, depending on whether you want to discharge warm or cool water. With the surface outlet gate closed, water comes through the bottom gate, rises to the top of the trickle tube, where it is discharged to the outlet pipe. With the surface gate open, water flows directly into the trickle tube.

Occasionally you may need to completely drain your trout pond to repair the dam, harvest fish, clean the pond, or to remove undesirable fish. You should incorporate a drain pipe on the trickle tube system to make it easy to drain the pond.

There are two types of trickle tubes: *standing in open water* (Fig. 5) and set on a dam (Fig. 6).

The *standing in open water type* is a pipe sur-

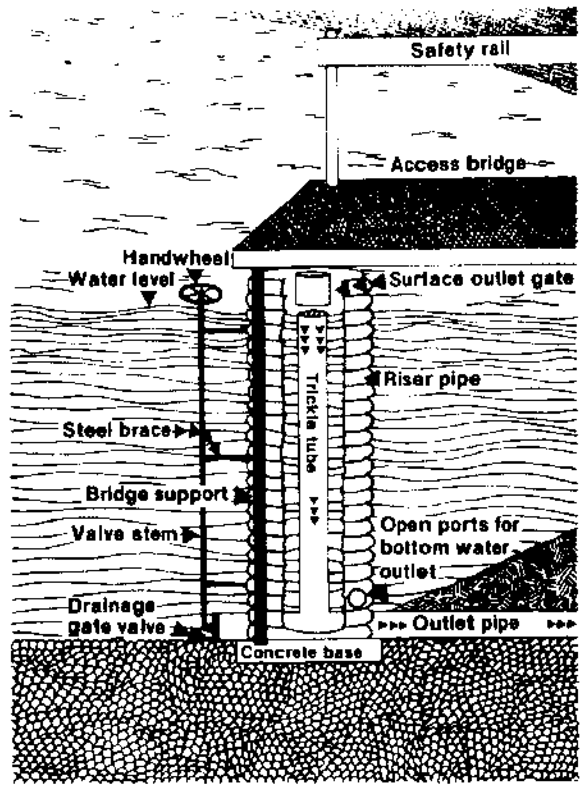

Figure 5. Trickle tube designed to allow outflow from either the surface or bottom of pond.

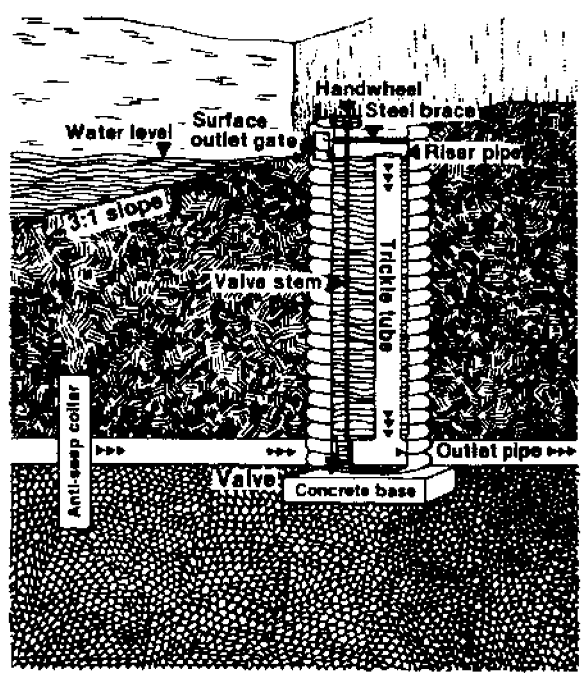

Figure 6. Where ice protection is needed, install trickle tube within the earthfill dam.

rounded by a riser pipe with space between the two having at least as much water capacity as the trickle tube. The outside pipe should extend 6 inches above the inside trickle tube. The entire system is located in the deepest area of the pond and set on a concrete foundation. Bottom and surface outlet gates will permit you to control the discharge of cool or warm water. In colder areas, ice may damage open water trickle tubes, even if they are supported by a post or catwalk.

The *set on a dam type* is used if the pond is in a cold area where ice might damage an open water trickle tube. A large riser pipe can be set in the dam supported on a concrete foundation that is set as deep as the deepest area of the pond. The trickle tube is again located inside the large riser pipe and surface and bottom gates are located as shown in Figure 6.

Your outlet pipe can be plastic, concrete, or clay with a cutoff collar every 10 to 20 feet to prevent water from seeping along the pipe. Extend the spillway pipe 10 feet or more beyond the dam, with a stone or concrete apron at the outlet end to prevent erosion.

Habitat Protection

Pond installation may greatly change the surrounding plant, animal, and aquatic communities. Keep in mind the effect of your pond intake and outlet water on other aquatic animals and try to preserve as much natural vegetation, particularly trees and shrubs, as possible during pond construction. Careful advance planning helps prevent the destruction of adjacent natural habitat.

Building the Pond

Clear all stumps, brush, and debris from the pond site. Prepare a foundation for the dam by removing the sod and topsoil to a depth of at least 6 inches to ensure a sound base on which to build your fill.

Your earth dam may require a core trench filled with an impervious material to prevent water from seeping under the fill. The depth of this core trench will depend on the soil type and the underlying material, which should be determined by analyzing soil borings. The core trench should go down to a water-tight soil for the continuous length of the dam and should extend into the natural banks on either end. It should be at least 4 feet wide. Fill the core trench with moist and impervious clay, spread in 6-inch layers, and packed thoroughly with a sheepsfoot roller or by repeated trips over it with construction equipment (Fig. 7).

The remaining fill for the dam should be moist soil spread in 6 to 8 inch layers and compacted with a sheepsfoot roller or construction equipment. Do not use soil that is too dry or too wet as it will not pack down properly. The top of the dam should be at least 8 feet wide (see Table 2) with a downstream slope of 2 to 1 (2 feet horizontal for every 1 foot rise), and an upstream slope of 3 to 1.

Table 2. Dam Width as Related to Height

Height of dam (Ft.)	Top width (Ft.)
10 or less	8
11-15	10
15-20	12

When soil is very silty or sandy, slopes on both sides should be 3 or 4 feet horizontal to 1 foot vertical. The fill should be about 10 to 15% higher than the plans specify to allow for settling.

If rain stops your building operation, wait until the surface of the partly built dam is dry before you add more soil to it. This will prevent the formation of a seepage channel between the rain-packed surface and the new fill.

If the soil from which your dam is being built is very stony, place the stones in the lower third of the fill, tamp them in with clay, and do not allow them to accumulate in piles.

Laying the Pipe Spillway. When the pipe spillway is laid in the bottom of the draw to permit draining the pond, the pipe should rest on the bottom or preferably below the core trench. If this is not possible, be careful when back filling the core trench to prevent settlement under the pipe. Place collars of poured concrete or other ma-

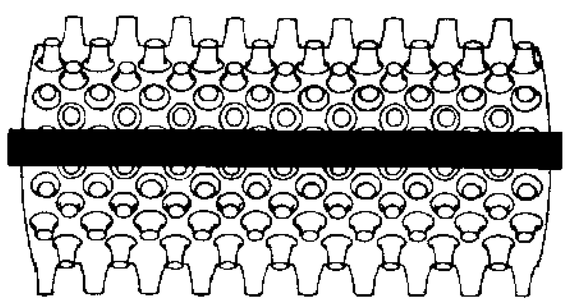

Figure 7. A sheepsfoot roller will help compact the soil used in pond construction.

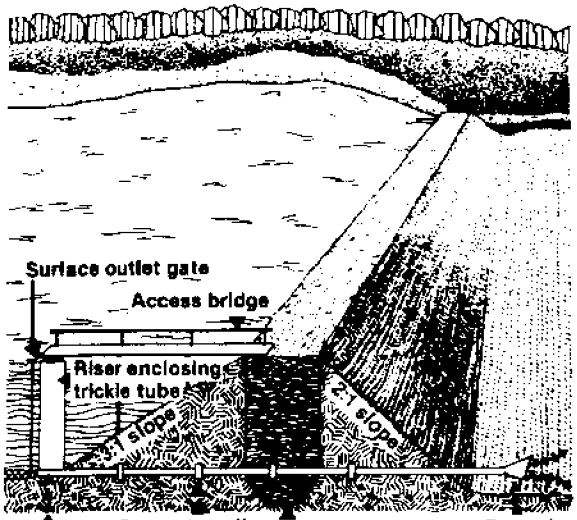

Figure 8. Cross section of an earthfill dam showing surface and bottom water outlet control system.

terials every 10 to 20 feet, then tamp clay soil firmly around the pipe.

Making the Side Spillway. Usually the side spillway is made during the construction of the dam, using excavated soil for fill if it is suitable. The spillway should be flared at the inlet end. It should lead around the end of the fill, not over it and empty in a well-sodded area.

Finishing the Pond. After the dam and spillway are completed, seed the area with a grass mixture and fertilize if necessary. The pond should remain empty until a good grass cover is well established to prevent erosion.

Grade all edges of the pond before it fills with water. The edges should have about a 2 to 1 slope and the grading should extend about 3 feet below the normal water level. This grading will help to eliminate swampy conditions and undesirable weed growth around the pond.

Finally, plant grass, shrubs, or other vegetation around the shoreline of the pond. With a little landscaping you can make your trout pond one of the most attractive spots on your property. Mixed clumps of evergreen and deciduous trees bordered by shrubs and open grass areas will provide a beautiful area for outdoor recreation. A grass or shrub border around the pond protects it from erosion and silting, helps ensure a clean supply of runoff water, and provides habitat for desirable wildlife. Trees that will help shade the pond from direct summer sun are desirable.

Building an Excavated Pond. An excavated pond is the simplest to build and the only kind that can be built economically on nearly level land. It has the advantage of exposing a minimum amount of surface area in proportion to its volume, and no spillway is required. Excavated soil can be piled along the edge of the pond, then seeded with grass to prevent erosion.

Sealing a Leaky Pond. Often the only suitable site for a pond will have soil that may cause a water leakage problem. If the pond is located over layers of sand or gravel, the seepage may be so great the pond will not hold water. Gradual seepage in new ponds may subside after silt has coated and sealed the bottom. However, it is sometimes necessary to drain and rework the pond bottom.

Bentonite, a moisture-absorbing mineral clay, is a good way to seal a leaky pond. When worked into the pond bottom soil it swells upon contact with water, filling in between soil particles.

There are two ways to use Bentonite: 1) Drain the pond and let it dry. Smooth the bottom, filling holes and crevices and removing rocks and roots. Plow or disk to a depth of about 6 inches. Spread 100 to 150 pounds of Bentonite evenly over each 200 square feet of bottom and rake or disk it to a depth of about 3 or 4 inches. Roll the area several times to pack the soil before refilling the pond. 2) When you can't drain the pond, spread the coarse crushed form of Bentonite over the surface of the water at a rate of 1/2 to 1 1/2 pounds per square foot of surface. As the particles settle, a gel is formed which seals the bottom of the pond.

Pond Maintenance

Regular inspection and maintenance of the pond will prevent expensive repairs. Keep the grass or plant cover in good condition, reseeding bare spots, if necessary, to prevent erosion. Examine the dam and pipe system for damage from burrowing animals, or wave action, and keep livestock out of the pond or isolated in one small area of shoreline.

FISH MANAGEMENT

Species Selection for Stocking

Rainbow trout are most commonly stocked in Washington because they thrive under a wide range of conditions, grow faster than other trout species, and are more widely available from hatch-

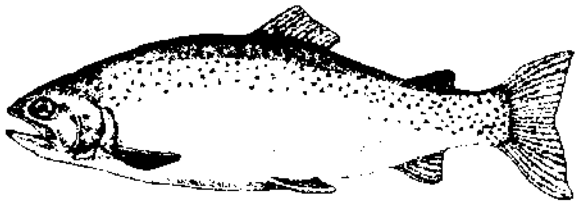

Figure 9. The rainbow trout is often used to stock ponds in the state.

eries. Stocking brook, brown, or cutthroat trout is not recommended. Trout are often unable to compete successfully with most other fish in a pond because these fish multiply rapidly and compete for the available food. If undesirable fish are already in the pond, drain it and remove them before stocking with trout.

For successful trout fishing, try to prevent the escape of your trout and the invasion of other fish into your pond. The trickle tubes described in the section on outlets will keep fish from leaving or entering your pond via the outlet. You may want to install a grate over the inlet, to keep fish from moving in or out. This can be made of rods, pipe, or strap iron welded onto a frame and set in concrete at an angle of 30 degrees. Water current moves debris toward the top of the grate where it is easily removed with a rake. Spacing of the rods determines the size of the fish that will be controlled, but don't set the rods closer than one-quarter of an inch apart, as this will interfere with water flow.

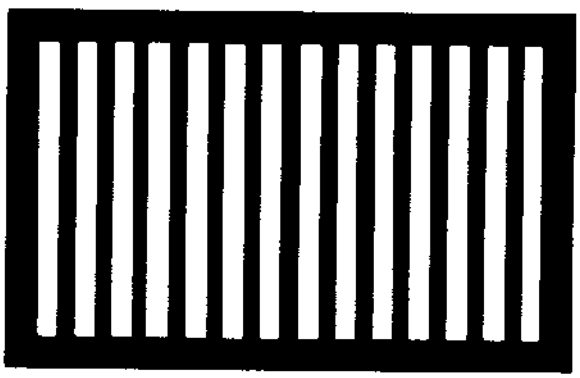

Figure 10. A grate placed over the inlet keeps your fish in and other kinds out.

Stocking

Before stocking, decide whether you will feed the trout an artificial pelleted trout food or let them rely on the natural food available in the pond. Supplemental feeding will increase the growth rate and production of fish in your pond, but it will be more expensive (see Supplemental Feeding on page 11).

The fertility and quality of water, surface area (not volume), and length of the growing season determine the carrying capacity of your pond when artificial feeds are not used. Carrying capacity is simply the number of pounds of fish that your pond will support. You can't measure the carrying capacity of your pond accurately, but for practical purposes you don't need to. If your stocking number is slightly low, the fish will grow faster. If your pond is slightly overstocked, the individual fish may not grow as fast, but nearly as many pounds will be produced in a given time.

Either spring fingerlings (2 to 3 inches long, 2 or 3 months old) or fall fingerlings (5 or 6 inches long, 7 or 8 months old) can be used in stocking ponds. Both types reach catchable size the spring following stocking. However, results with spring fingerlings are variable, sometimes resulting in poor survival except in ponds fed by strong permanent springs containing no competing fish. Therefore, it is usually wiser and more economical to stock the larger fall fingerlings.

Stocking at the rate of 100 to 200, 5- to 6-inch fingerlings, or 200 to 400, 2- to 3-inch spring fingerlings per surface acre gives good results in most fertile ponds. Another alternative is to stock 300 to 400, 3- to 4-inch fingerlings in the spring so that you will have 8- to 10-inch trout by late summer or fall. If you are unsure of the quality of water or carrying capacity of your pond, use the lower stocking rate.

With these stocking rates and favorable conditions, your trout should grow about 1 inch a month until they are 9 to 10 inches long. Growth rate generally decreases as the fish grow older and is somewhat faster in summer than in winter. Trout grow at different rates in different ponds and usually grow slower for the first few months after the pond is filled, before a good insect population is established. Also, trout tend to grow more slowly in soft water than in hard water.

You can stock eating size trout at about 100 to 200 per surface acre. This is a quick way to get fishing, but it is very expensive compared to stocking fish fingerlings.

Take special precautions to ensure that the trout are properly transported from the hatchery and enter the pond in good condition. Consult the hatchery operator about the number and size of

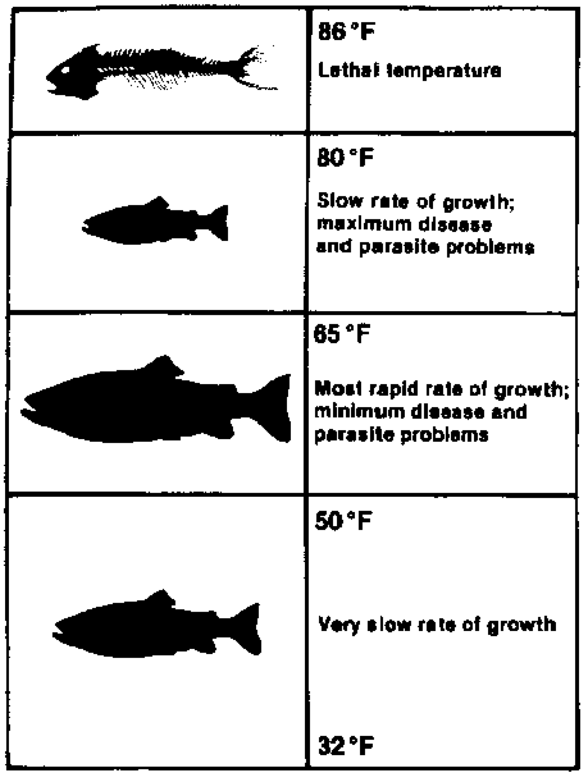

Figure 11. Trout do best in 50-65° water.

containers to bring along. Clean plastic garbage cans with covers can be used to transport trout at the rate of 100 fingerlings per 30-gallon can. The hatchery may be able to deliver the fish in a special tank truck.

Transport trout only in cool weather because tank water should be kept below 55 °F. If necessary, ice can be packed around the container, or chlorine-free ice can be placed in the water. Oxygen-producing tablets or aeration may be necessary if the fish are to be transported a considerable distance.

When stocking the fish, place the container in the pond and tip it gently on its side so the trout can swim out. Never plant them near the overflow pipe. If the temperature of the water in the pond differs from the transport tank by more than 5 °F, gradually acclimate the fish to the pond temperature during 30 to 60 minutes. Acclimation can be done by slowly adding pond water to the transport tank.

Survival

Survival of pond trout that are not fed on artificial pelleted food varies with pond conditions and climate and depends on the size of fingerlings stocked. During the summer following stocking, the survival is highly variable averaging about 30%. Annual survival after the first year is usually less than 50% (Fig. 13).

The total poundage of trout present in a pond at any one time is the net result of two opposing factors: growth, which increases poundage, and deaths, which reduce it. When the growth rate exceeds the death rate, poundage increases, and vice versa. In Figure 13, you can see the total poundage reaches a maximum of 110 pounds per acre by the fall of the first year after stocking, when about 230 trout remain. One year later, only 41 pounds and 45 trout are left; over 90% of the stocked fish in an unfished pond will have died 2 years after stocking. Therefore, for maximum yield, a pond owner should harvest as many trout as possible during the first 2 years.

The longer an owner waits before starting to harvest his trout, the lower the yield will be. Consider the example of Mr. Right and Mr. Wrong, who start out with identical ponds, each stocked with 600 fall fingerlings. In the first year after stocking, Mr. Right harvests 165 trout, but Mr. Wrong wants his fish to get larger and does no fishing. The second year, both owners fish equally hard and catch equal percentages of the trout pop-

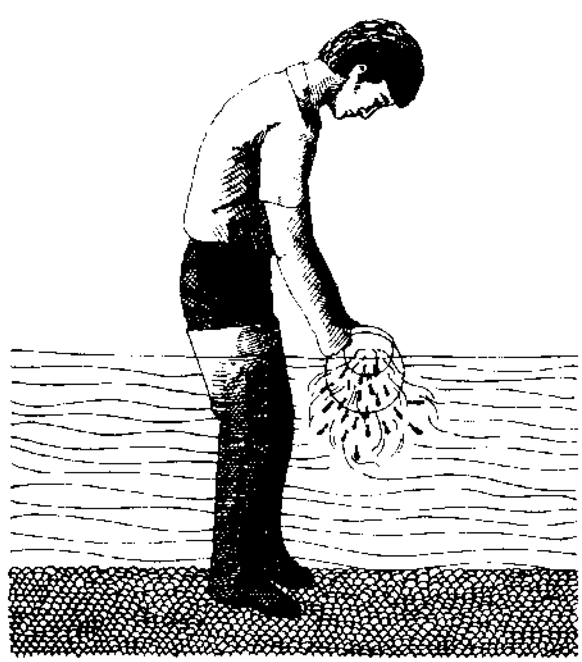

Figure 12. Place container in the pond and gently tip it to release fish.

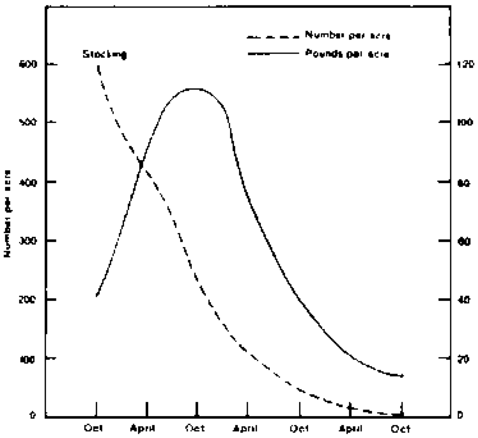

Figure 13. Numbers and pounds of trout that remain in an unfished pond following stocking with 600 fall fingerlings per acre.

ulation. Table 3 shows the number of fish caught and remaining in each pond.

Table 3. Fish Production Under Two Harvest Systems

Time	Mr. Right Caught	Mr. Right Left	Mr. Wrong Caught	Mr. Wrong Left
1st year after stocking	165	115	0	230
2nd year after stocking	35	5	70	10
Total catch	200 (75 lb.)		70 (50 lb.)	

Although Mr. Wrong caught twice as many 2-year old fish as Mr. Right, Right's total catch was nearly three times as great in numbers and about 50% more by weight. In addition, the difference between the number of fish left in the two ponds at the end of the second year was insignificant.

Large 2-year old trout remaining in the pond at restocking usually eat some of the newly planted fingerlings. To minimize this predation, fish trout heavily during the second year following stocking.

Trout harvesting schedules are largely a matter of personal preference. Table 4 gives a rough estimate of the number of trout available for harvest the second year when various numbers were harvested the first year.

Remember that these figures are for 1 surface acre and that survival in your pond may be different than the figures in the table.

Pond trout are usually much easier to catch in spring or fall, using flies, worms, or spinning gear. There are no restrictions or required licenses on fishing in an artificial water course, so you may want to fish year round. Seining or completely draining the pond may be necessary to harvest every fish.

Table 4. Relation Between Number of Trout Harvested in the First Year After Stocking and Number that Could Be Harvested in the Second Year.

Harvested in 1st year	Number of trout per acre available for harvest 2nd year when stocking rate was 300/A	600/A
0	35	70
50	25	60
100	15	50
150	5	40
200		30
250		20
300		10

Supplemental Feeding

Dry pelleted trout feeds are available from many feed manufacturers, and regular daily feeding can increase production to 1,000 pounds or more per acre. The use of supplemental feed will provide better fishing, but at a greater cost (currently 40¢ per pound). It is only recommended in ponds with adequate freshwater supplies.

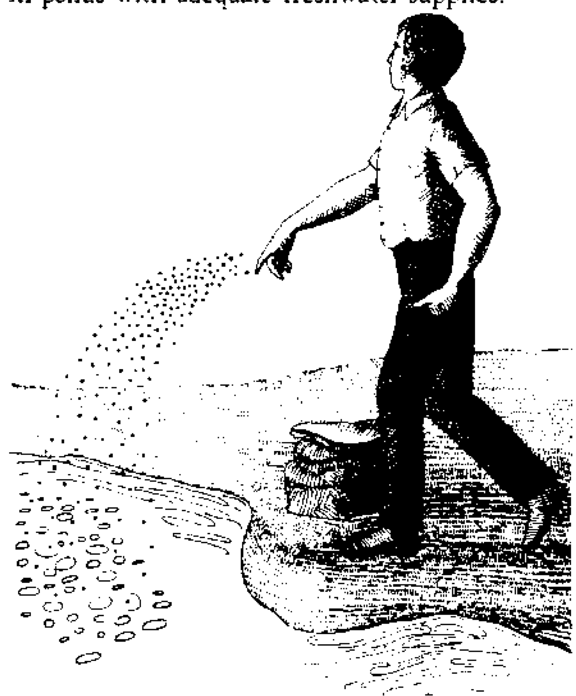

Figure 14. Feeding dry pellets daily can increase fish production.

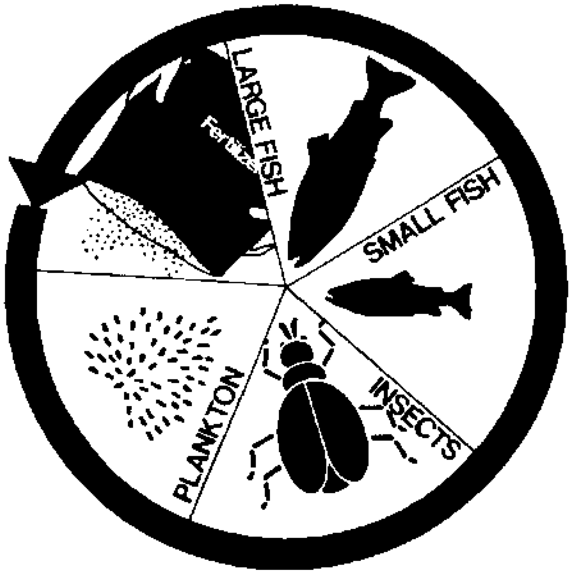

Figure 15. Fertilizing the pond produces plant and insect food for the fish. Smaller fish often become food for the larger ones, which end up as a meal for the pond owner.

Ponds should be stocked with 2000 to 3000 fall fingerlings per acre and fed regularly every day to obtain rapid and constant growth. Feed small fingerlings, 2 to 3 inches long, three or four times a day; 4- to 5-inch fish twice a day; and larger trout once or twice a day.

The amount of feed needed by the fish will vary with their size and the temperature of the water (Table 5).

Table 5. Feed per 100 Pounds of Fish at Water Temperatures Between 55° and 65°F

Size	Weight of food
Small fingerlings	4 lb./day
3-6" trout	3 lb./day
7-10" trout	2 lb./day

Reduce the weight of food to one-half when waters are 45°-50°; and to one-fourth when water is only 40°-45° or greater than 65°F. Don't feed at all when the water stays between 32° and 39° F. Water quality, particularly dissolved oxygen, should be closely monitored. Don't overfeed, as this will lead to water quality problems.

Survival of pond trout fed an artificial pelleted food is better than that of trout in a natural pond and can be over 80% with proper feeding and good pond water quality.

Reproduction

Trout rarely reproduce naturally because most ponds lack a suitable spawning site; a gravel area through which a good flow of water percolates during the incubation period, supplying the eggs in the gravel with clean oxygen-rich water, and keeping them from being smothered by silt and debris. A small stream flowing into the pond can be developed for a spawning channel. However, a small trout hatchery for hatching eyed eggs is easy to construct and operate with a relatively small, dependable water supply. Eyed eggs are much cheaper than fingerlings, and you may want to sell sur-

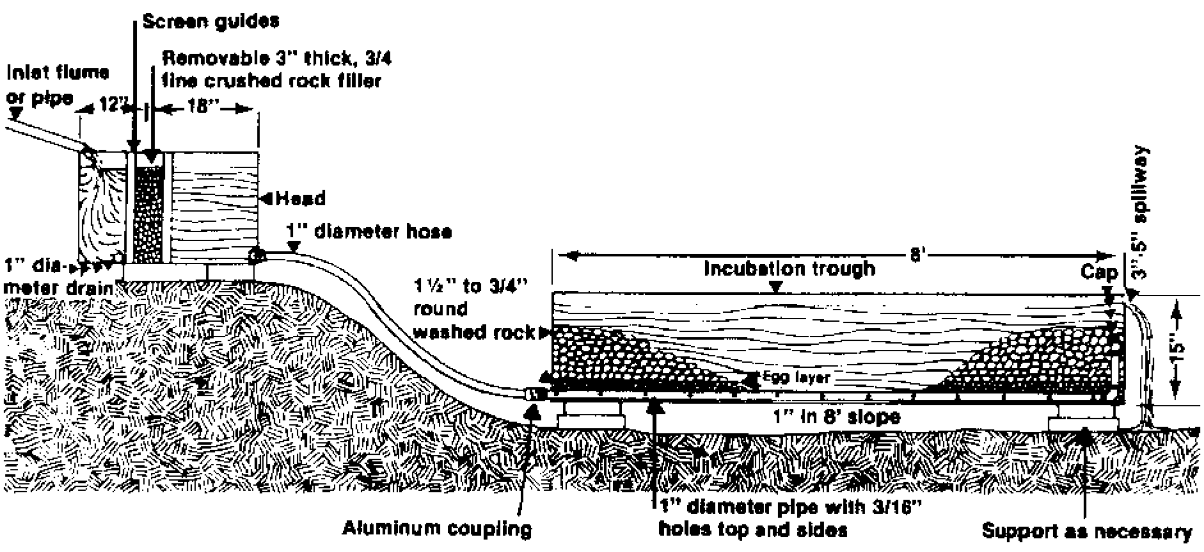

Figure 16. Diagrammatic section of an incubation facility.

plus fingerlings you raise from eyed eggs to other trout farmers. Several of the references listed on page 18 give detailed descriptions of the construction and operation of trout hatcheries.

Restocking

Without supplemental feed, few trout survive beyond 2 to 3 years of age, and restocking should be done every 2 to 3 years to maintain adequate fishing. Fall fingerlings are recommended for stocking because they are less likely to be eaten by large holdover trout and are more likely to survive than small fingerlings.

The pond can be restocked either with 400 fingerlings per acre every 2 years, or with 300 fingerlings per acre each year. Stocking each year with 200 fall fingerlings will maintain a more even mixture of 1- and 2-year-old trout.

Fed trout grow more slowly as they get older and should be harvested before they are 2 to 3 years old.

Fertilizing Ponds

In some cases, an application of 300 pounds of 16-20-0 fertilizer per acre may increase trout growth because of the increase in plant and insect life. Such an application in a newly dug pond may hasten the establishment of a natural food supply.

However, a great deal of caution must be used when applying fertilizer, because too much will cause excessive plant growth, leading to chronic water quality problems, such as lack of oxygen and an increase in turbidity. Do not fertilize if you are feeding your fish.

Pond Maintenance

Water Quality. Poor survival of pond fish may be the result of poor quality water. Partial or complete fish kills are not uncommon and the following information may give you an indication of the cause and remedy.

1. *Oxygen depletion* is caused by an overabundance of living or dead plant material in the pond. For respiration, fish require a sufficient amount of oxygen dissolved in the water. In the summertime, during the early morning hours before light, plants and decaying organic material remove large quantities of oxygen from pond water. Fish suffering from suffocation will be gasping at the surface, and may die with mouths open and gills flared. Some pond owners add oxygen and lower water temperature by pumping water from the pond and returning it through sprinkler heads. You can buy special aerators for this purpose.

   Kills from oxygen depletion usually occur in small ponds with dense plant growth. To lessen the chance of this problem, provide adequate depth, avoid heavy fertilization, and control weeds, particularly in late summer.

   If ice and snow cover the pond for more than a month, winter kill of trout may result from lack of oxygen or from toxic gases. To reduce or eliminate winter kill:
   - reduce aquatic vegetation before winter ice forms
   - provide some inflow of water during the winter to provide oxygen
   - drain foul gas laden bottom water from the pond through the bottom outlet pipe
   - aerate with compressed air
2. *High water temperature.* If water temperature remains higher than 75°F, for a number of days, fish may appear sluggish or very inactive and eventually die. A deeper pond or increase in incoming water will usually solve this problem.
3. *Toxic materials.* All too frequently fish are killed by chemical contaminants, such as insecticides or weed killers that have entered the pond water. Use caution when using any chemical within 200 feet of the pond or in the immediate watershed area.

Parasites and Diseases

Fishes, like all animals, have natural abilities to ward off disease organisms, and it is usually when these defenses break down that the fish becomes infected. The best way to prevent disease problems is to maintain a good environment for your trout. This means good quality water, with enough oxygen and proper temperature, as well as adequate food and pond space.

Parasites and diseases are usually only a serious threat in intensive production situations where they can spread rapidly. There are few satisfactory treatments for disease problems and accurate diagnosis requires some technical training. For advice and assistance contact state and federal fisheries biologists, or the U.S. Fish and Wildlife Service, National Fisheries Research Center, in Seattle. There are several good referencess on parasite and disease diagnosis and control in the bibliography.

Weed Control

Aquatic vegetation is found in most lakes and ponds and provides food and cover for aquatic organisms, produces oxygen, and stabilizes bottom sediment. However, excessive weed and algae growth can destroy the appearance and function of a trout pond.

Preventing and controlling water weeds begins with the design and construction of your pond. Deep banks with at least a 2 to 1 slope extending into water that is 3 feet deep will help to prevent the establishment of many emergent and bank weeds. A good grass cover will also discourage undesirable weed growth.

In spite of these precautions you may still have some weed problems. Mechanical control, such as mowing or pulling may be adequate. Information on locally approved chemicals for aquatic weed control is available from your county Cooperative Extension office.

OTHER POND USES

A well-designed trout pond can be used for many things other than fishing. You can make a beach and swimming area, use the water for livestock or fire protection, or make the area suitable for wildlife.

Swimming

A small swimming beach with a gradual slope of 5:1 can be constructed for ponds of a half acre or more with little or no harm to fish production. To prevent the growth of aquatic weeds, cover the bottom of the beach area with plastic, and cover the plastic with 4 to 6 inches of gravel or coarse sand. Small mesh plastic window screening also works well to control weed growth.

Wildlife

To enhance the pond area for wildlife, provide a variety of vegetation in surrounding areas. The shore should contain mowed areas, some brush, and a few trees, and you may want to provide food by planting some corn or other crop plants.

Irrigation

Pond water is sometimes used for irrigation if the pond is spring fed. However, if the water supply is principally from runoff, pond levels may become low during the summer. Additional water loss to irrigation might harm fish as well as cause other problems.

Water for Livestock

If the pond is to be used for livestock, they should be restricted to one area of shoreline or preferably use a watering area below the dam. In this case, a pipe with a float valve supplies the water. Shoreline watering areas should have a good gravel bottom to prevent the breakdown of the bank and muddying of the water.

Fire Protection

To use pond water for fire protection, an all-weather access road should be constructed so that a pump truck can get to the pond.

LEGAL ASPECTS AND PERMITS

Local and state government permits are necessary to protect and manage the state's natural resources. They can be confusing and complicated if you are not familiar with them.

During the planning stage of your pond, check with your county planning office to determine if local permits are required. For state permits, the Environmental Coordination and Procedures Act (ECPA) Section of the Washington State Department of Ecology will assist you through their master application procedure. Contact the ECPA Master Application Center in Olympia (Tel. 206—753-2800) or your nearest Department of Ecology Regional Office.

You may need one or more of the following permits from these state agencies:

Washington Department of Ecology

Water Rights Permit—for withdrawing water from a State stream.

Water Discharge Permit—regulates the discharge of water into the state's ground waters.

Reservoir Permit—required for ponds over 10 surface acres, or with a dam of over 10 feet in height.

Washington Department of Game

Game Form 96—authorization to plant trout (allow 2 months processing time).

A biologist is available to assist the owner in pond planning and managing.

Game Farm License—required for a commercial trout operation.

Hydraulics Permit—required if working in state waters.

Washington Department of Fisheries

Hydraulic Permit—required if working in state waters.

Aquaculture Permit—required for any salmon aquaculture operation.

ECONOMICS

Enterprise Budget for Wholesale Dressed Trout Production

The following budget presents costs and returns information for producing and marketing trout in Washington. This information will be helpful to producers, lenders, and others interested in making better business management decisions, including profit planning, financing, marketing, and resolving numerous related business management problems.

This budget does not represent a particular trout farm. Instead it represents costs and returns under the specific assumptions outlined in this budget. If actual production and marketing circumstances vary from those specified here, then different results can be expected. This budget is offered to indicate typical production practices and to provide a sample format for assembling an enterprise budget. It is recommended that individual producers use the blank spaces provided to adjust the budget information to their circumstances.

The following assumptions were used in preparing this budget information:

1. 20% mortality from egg to harvest;
2. 1:1 feed conversion ratio;
3. Harvested dressed fish weigh 1/3 pound each;
4. All labor hired except for repairs done by owner;
5. Fish are marketed wholesale as dressed fish.

Trout enterprise budgets are presented in three tables. Table 6 is a summary of costs and returns. Gross returns of $26,400 result from selling 17,600 pounds of dressed fish at $1.50 per pound. Itemized cash costs total $18,335. Subtracting cash costs gives a return over cash costs of $8,065. Subtracting fixed costs, interest and depreciation, provides a return to management of $4,236.

Table 7 is a schedule of depreciation, interest, and repair charges. The required investment includes 1 acre of land valued at $5,000 that contains a ½ acre excavated pond, plus the following improvements: a 200 square foot hatchery and processing building, a 50 square foot feed storage

TABLE 6. COSTS AND RETURNS FOR COMMERCIAL TROUT PRODUCTION

		Your values		Your values
Returns				
17,600 lb. fish @ $1.50			$26,400	———
Cash Costs				
Repairs	$1,216	———		
Repair labor 60 hours @ $5.00	300	———		
Eggs 66,000 @ $43/1000	2,840	———		
Feed 22,000 lb. @ $.25/lb.	5,500	———		
Electricity 450 kwh, $186.00 month	2,232	———		
Labor (feeding, processing, marketing, etc.) 744 hours @ $5.00/hr	3,720	———		
Insurance and license	1,000	———		
Miscellaneous, 5% of cash costs	782	———		
Interest on cash costs @ 12%*	745	———		
Total Cash Costs	$18,335			
Return Over Cash Costs			$8,065	———
Fixed Costs				
Interest on average investment	$2,139	———		
Depreciation on buildings & equipment	1,690	———		
Return to Management			$4,236	———

*Average cash expenses outstanding December through October at 12%.

TABLE 7. DEPRECIATION, INTEREST, AND REPAIRS—COMMERCIAL TROUT BUDGET

1	2	3	4	5	6	7	8	9
Item	Original value or cost	Salvage value	Average* value	Years of life	Interest @ 10%	Depreciation†	Annual repairs as a % of value	Annual repairs
Land—1 acre	$5,000	—	—	—	$500	—	—	—
Pond—½ acre	$10,000	$1,000	$5,500	15	550	$600	2	$200
Raceway—8' x 100'	800	40	420	15	42	50	2	16
Hatchery and processing—200 ft.^{2}; Feed storage bldg.—50 ft.^{2}	5,000	1,000	3,000	20	300	200	5	200
Well, pump, motor & pipe (25 HP, 1000 GPM)	9,000	2,250	5,625	15	562	450	4	360
Hatchery & Harvesting equip.	1,200	0	600	5	60	240	20	240
Refrigeration equipment	2,000	500	1,250	10	125	150	10	200
TOTALS	$33,000	—	—	—	$2,139	$1,690	—	$1,216

*Average value $= \dfrac{\text{Original Cost} + \text{Salvage}}{2}$

†Straight line depreciation $= \dfrac{\text{Original Cost} - \text{Salvage Value}}{\text{Years of Life}}$

TABLE 8. CASH FLOW & MONTHLY LABOR REQUIREMENTS

Item	Total	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Cash Receipts													
17,600 lbs @ $1.50	$26,400											$26,400	
Cash Expenses													
Repairs	$1,216	$200				$200	$200	$200	$100	$100			$216
Eggs, eyed	2,840											$2,840	
Feed	5,500					400	600	700	900	1,100	$1,200	600	
Electricity	2,232	186	$186	$186	$186	186	186	186	186	186	186	186	186
Labor, all	3,720	60	200	200	250	200	200	200	200	200	150	1,800	60
Insurance & license	1,000							1,000					
Miscellaneous	782	67	65	65	65	65	65	65	65	65	65	65	65
Interest on cash expenses	625						625						
Monthly Net	$8,485	(513)	(451)	(451)	(501)	(1,051)	(1,876)	(2,351)	(1,451)	(1,651)	(1,601)	$20,909	(527)
Labor Hours	744	12	40	40	40	40	40	40	40	40	30	360	12

facility with a capacity for $2\frac{1}{2}$ tons of feed, pump, motor and well, refrigeration, and hatchery and harvesting equipment.

Table 8 provides monthly cash flow and labor requirements. Eyed eggs are purchased in November and fish produced during the previous year are processed and marketed wholesale in November. Approximately 711 annual labor hours are required with nearly half of these hours needed in November.

Marketing

There are three basic marketing outlets for trout. The wholesale dressed fish is assumed in the previous budget.

1. Fish Out
   The pond is open to the public for individual harvesting of fish. Poles and gear are usually provided, and fish are killed, cleaned, and wrapped for the customer. As with other retail operations, someone must be available to help customers with their catch, clean fish, and handle money. Facilities such as parking space and restrooms must be provided and fish are sold in the round for $1.50 to $2.00 per pound. This type of operation can vary in size from a small seasonal backyard pond to a large combination retail wholesale business, depending on the demand for fish in the area.

2. Wholesale—Dressed Fish
   Fish are harvested, cleaned, and sold to seafood wholesalers, restaurants, or retail outlets. Usually a substantial and steady supply of fish is necessary to maintain this market, which can only be provided by a large operation with processing facilities. Workers should be able to clean 200 fish per hour, and fish are then packaged and refrigerated until delivery. Prices for dressed fish vary from $1.45 to $1.65 per pound.

3. Live Fish Sales
   Trout fingerlings or adults are raised for stocking farm ponds or for sale to larger aquaculture operations. A truck with suitable tanks is required, and live fish sell for $1.50 to $2.00 per pound, depending on their size. Salmon fingerlings may be raised on contract with larger aquaculture companies.

Often a combination of marketing schemes will be used in a single operation, depending on the season, size of the operation, and other circumstances.

PUBLICATIONS

Culture and Diseases of Game Fishes
By H. S. Davis, published by University of California Press, P.O. Box 1588, Richmond, California 94800 ($6.50)

Trout Farming L 552
By David B. Greenberg, through U.S. Trout Farmers at $8.50, Published by Chilton Company, Philadelphia, Pennsylvania 19100 ($12.50)

Trout and Salmon Culture
By Earl Leitritz, published by State of California Fish & Game, Fish Bulletin 107, Sacramento, California 95800 ($3)

Trout in Farm and Ranch Ponds
By Paul Scheffer, Farmers Bulletin 2154, Publications Division, Office of Governmental and Public Affairs, U.S. Department of Agriculture, Washington, D.C. 20250 (free)

How To Build a Farm Pond
By Walter Atkinson, Leaflet 259, Publications Division, Office of Governmental and Public Affairs, U.S. Department of Agriculture, Washington, D.C. 20250 (free)

Have Fun with Your Own Trout Farm
Published by U.S. Trout Farmers Association, 67 West 9000, South Sandy, Utah, or Jumping Rainbow Ranch, Box 848, Livingston, Montana 59074 (50¢)

How To Raise Trout for Fun and Profit
By Paul B. McAdam, published by Jumping Rainbow Ranch, Box 848, Livingston, Montana 59074

Fish Health Management
By George Klontz, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, Idaho 83843 (2 vols $12.50)

American Fishes and U.S. Trout News (Trade Magazine)
U.S. Trout Farmers Assn., 1730 Pennsylvania Avenue, N.W., Washington, D.C. 20006

ASSISTANCE AVAILABLE

Where to Go for Help

You will probably need some advice and assistance during the planning, construction, and management phases of your trout pond. The local Washington State University Cooperative Extension office, USDA Soil Conservation Service (SCS) office, and Washington Department of Game should be able to help you with most of the questions and problems that you will encounter.

Planning

A representative of the SCS may be able to determine the feasibility of an area for a pond, provide engineering help, and make plans for the pond and required structures.

Construction

The Agricultural Conservation and Stabilization Service of the USDA has a limited cost-sharing program for constructing ponds for the production of fish. However, any pond constructed that qualifies for federal cost-sharing does not prevent its use for fish production.

Financing

The Farmers Home Administration (FmHA) has several loan programs for aquacultural operations, including ownership and operating loans. Contact your county FmHA office or FmHA, U.S. Department of Agriculture, Washington D.C., 20250 for details.

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